

THE RAINS OVER ARIZONA, AUGUST 26-29, 1951

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INTRODUCTION

On August 26, 1951, showers and thunderstorms occurred over southern Arizona bringing to a temporary end a prolonged period of above normal temperatures. During the succeeding three days the area of precipitation expanded as the thunderstorms gave way to a more steady type of rainfall. Low maximum and minimum temperatures were noted during the rain period with some stations reporting record, or near record, low maximum temperatures.

This article will present the results of a brief investigation into the causes of this unusual weather.

MAJOR CIRCULATION INFLUENCE

The rain over Arizona presents an interesting example of the connection between the weather at one point and the weather at another; in this instance, the rain in Arizona and the heat in Texas.

Throughout August very dry weather prevailed over Texas as the land lay in the grip of one of the most persistent periods of heat in its history. Temperatures, over the State, ranged from the nineties to the hundreds throughout the entire month. Under clear skies the air was heated to high levels and helped maintain a warm, circular High, aloft, over west Texas and the west Gulf region. Toward August 25, 1951, this High increased in size to the extent that it covered the entire Gulf and the ocean areas adjacent to the west coast of Mexico [1].

At the surface the air moved over the warm waters of the Gulf of Mexico absorbing moisture as it went. Over the middle and northern half of the Gulf the air moved inland over Mexico curving anticyclonically as it approached the hills and mountains of the Sierra Madre Range (in northern Mexico, just west and parallel to 106° W. Long.). In time the anticyclonic curvature brought the air northeastward, on a downslope path, across New Mexico and Texas.

However, west of the Sierra Madre Range a different situation developed. Judging by the flow, some air from the lower Gulf of Mexico and air over the tropical waters off Central America joined forces to the west of the Pacific coast of Mexico. These winds, under the same influence as the air to the east of Mexico, moved poleward curving anticyclonically with time (fig. 1). Thus, we find air becoming more moist during a long fetch over warm

waters, picking up some of the moisture associated with the hurricane southwest of Lower California, acquiring additional moisture as it channeled northward, through the Gulf of Lower California, and finally, arriving at Yuma where the first topographical feature intervened.

THE ROLE OF TOPOGRAPHY

Once on land the air continued on the anticyclonic path, as directed by the pressure pattern, but was deflected somewhat to the left of the free air path by the influence of the terrain.

The land surface is lowest in the region of Yuma from where it rises to the east and north. To the east and northeast of Phoenix the land rises abruptly to form the Colorado Plateau. The effect of the land formation was such that the air moved northeastward over rising ground without too much interference until the western fringes

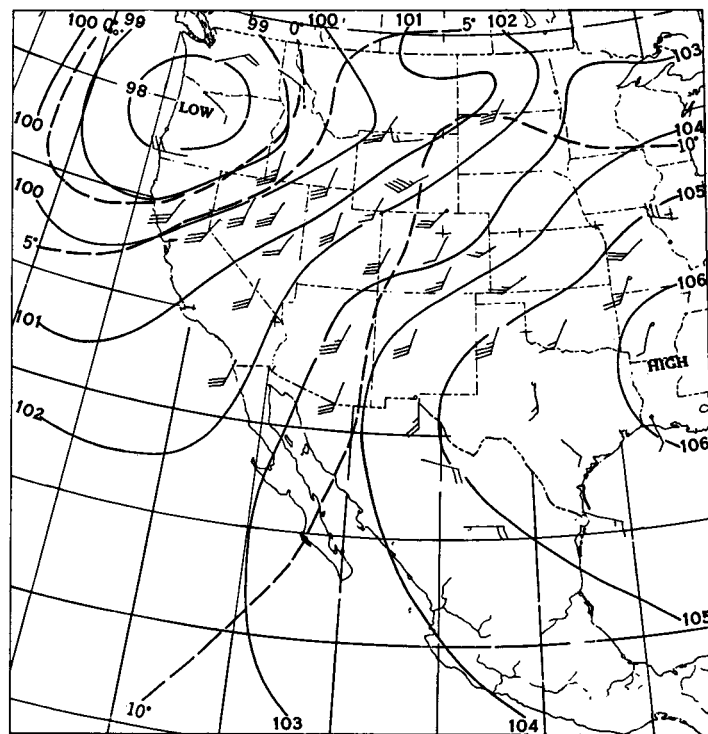


FIGURE 1.—700-mb. chart for 1500 GMT, August 29, 1951. Contours (solid lines) at 100-foot intervals are labeled in hundreds of geopotential feet. Isotherms (dashed lines) are at intervals of 5°C . Barbs on wind shafts are for speeds in knots (pennant=50 knots, full barb=10 knots, half barb=5 knots).

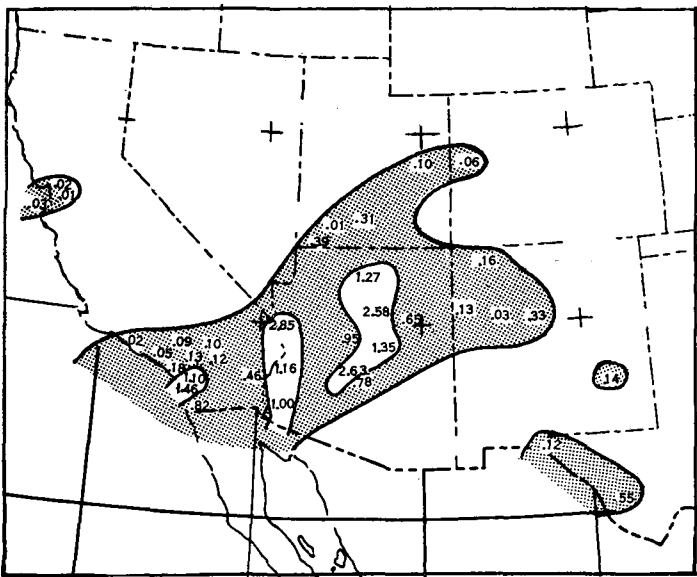


FIGURE 2.—24-hour precipitation ending 1230 GMT, August 29, 1951 (Shaded=Trace or <1 inch, encircled white=1 inch or more).

of the Colorado Plateau were reached. With this obstruction in its path, the air, still trying to move north-eastward, was deflected more to the north of its path in the Phoenix-Prescott region. This idea is supported by the reported southeast surface winds, during the rain period, at these stations.

SURFACE EFFECTS

Rainfall began on the 26th, as moist winds moved inland along the southwest border. The combination of hot ground, strong solar heating, and a low level of condensation in the rising air set the stage for the numerous thunderstorms which were reported by various stations. By late evening of the same day the strong convective stage was passed as was indicated by the absence of reports of thunderstorms and the frequent observation of showers and steady rain.

The rains spread across Arizona in a discernable pattern so arranged that the long axis of the heaviest precipitation pattern was orientated northeastward from the southwest border of the State, and then north across Flagstaff (fig. 2). Such an orientation suggests the topographical influences previously discussed. The heaviest falls were recorded along the axis and in, or near, the center of the line (near Flagstaff). Tucson was to one side of the main flow as revealed by the 3-day total of only 0.62 inch, which fell in 1 day. A second axis of flow existed on the 27-28th in the Yuma to Needles (Calif.) region. A tabulation of rainfall amounts and related data is presented in table 1.

When the month came to a close, Phoenix had received a total of 5.33 inches, marking the month as the wettest August in the 56-year history of the station. The rains of the 26th to 29th yielded the greatest total ever recorded

TABLE 1.—24-hour totals of rainfall for selected stations in Arizona, Aug. 26-29, 1951 (with comparative data)*

Station	Station elevation (above MSL)	Average monthly precipitation	24-hour total				Storm total	Previous record 24-hour total
			Aug. 26	Aug. 27	Aug. 28	Aug. 29		
Flagstaff	6,993	2.83	T	.10	2.28	1.62	3.00	1.92
Payson	5,000	2.15	2.00	2.12	2.12	1.53	7.77	.96
Phoenix	1,083	.96	.03	2.43	.84	.50	3.80	2.17
Prescott (WBAS)	5,014	2.82	.01	T	1.51	1.06	2.58	2.11
Tucson	2,558	2.17	T	.62	T		.62	1.50
Winslow	4,880	1.34	.07	.19	.94	.10	1.30	1.10
Yuma	203	.57	.05	.15	.68	.25	1.13	4.01

*Source—U. S. Weather Bureau, *Station Meteorological Summary* (for stations shown), August 1951.

during the month of August. Tucson had its heaviest total for August since 1946. At Payson a 43-year record for greatest total rainfall for any month was broken by the August total of 10.38 inches. Flagstaff reported the rain on the 28th was the greatest of record for any day in August.

The rain plus a thick layer of clouds produced interesting effects upon the temperature readings. Maximum readings dropped markedly under the influence of evaporation of falling rain, evaporation of rain from the ground surface, and cooling of the air by passage of cold rain through the lower layers of the atmosphere. These factors, added to a 3-day period of 9 to 10 tenths cloud cover over a large portion of the State, helped maintain relatively low temperatures.

At Yuma, for instance, the month was consistently above normal with maximum temperatures above 100° F. for the first 25 days of the month. From a high of 110° on the 25th to a high of only 80° (27th) was a sharp change for the residents, especially when it is recalled that the humidity on the latter date was quite high. Phoenix reported a maximum of 73° on the 27th after a period of 22 consecutive days of 100° or above. In fact the maxima of 73° (27th) and 76° (29th) were the lowest ever observed at Phoenix in any August. A tabulation of the maximum and minimum temperatures is presented in table 2.

TABLE 2.—Maximum and minimum temperatures for selected stations in Arizona, August 25-31, 1951*

Station	Maximum temperature (° F)							Minimum temperature (° F)						
	Aug. 25	Aug. 26	Aug. 27	Aug. 28	Aug. 29	Aug. 30	Aug. 31	Aug. 25	Aug. 26	Aug. 27	Aug. 28	Aug. 29	Aug. 30	Aug. 31
Flagstaff	80	80	63	58	57	69	73	37	44	46	51	49	44	38
Payson	93	86	63	70	63	77	82	58	57	56	55	50	47	48
Phoenix	104	100	73	83	76	92	93	76	72	68	68	67	65	69
Prescott (WBAS)	89	86	72	69	66	77	80	51	56	54	55	52	47	46
Tucson	100	88	73	86	88	91	94	76	70	66	71	71	68	63
Winslow	94	90	73	66	74	83	84	57	60	59	55	55	49	52
Yuma	110	99	80	87	93	95	100	72	73	72	71	70	71	72

*Source—U. S. Weather Bureau, *Station Meteorological Summary* (for stations shown), August 1951.

FEATURES OF THE SURFACE MAPS

A survey of the surface weather maps for August 26 to 30 yielded little of value as an aid to the explanation of the weather. Figures 3, 4, and 5 illustrate the relatively unchanging features of the surface pressure over the southwestern States. Two interesting features did come to light, however. The first, and not too surprising, effect was the disappearance of the thermal Low over Arizona, especially on the 27th. The second feature was a westward migration of a High cell which on August 26 had been centered over New Mexico. As the rain area spread, the High moved toward eastern Arizona where it persisted and grew in size till near the end of the period. This High was related to the western end of the upper level High which on the 27th extended from Florida to New Mexico, roughly parallel to 36° N. Lat.

To some extent the western periphery of the High was "fictional." As the temperatures dropped within the storm area, they soon reached values lower than the readings at stations outside the rain area. With such a situation two mountain stations, one in the rain and one outside the rain area, at the same altitude and observing approximately the same station pressure, but with a difference of 20° to 30° between their surface temperatures would report entirely different sea level pressure readings after reducing their station pressures. This, of course, would result from one station calculating a higher sea level pressure by using a relatively low value for the mean temperature of the air column from the station level to sea level.

The apparent spreading of the western side of the High wiped out the form of the heat Low. When the rains ended and solar heating once more took over, the edge of the High retreated from the southwest portion of the

State while the center itself moved north toward the Utah border.

LOWER TROPOSPHERE MOISTURE AND TEMPERATURE DISTRIBUTION

Graphs showing the vertical distribution of moisture at Phoenix were prepared, with figure 6 showing the period of increasing moisture. The curve for August 25 shows the moisture content on a dry day during which the temperature rose to 104° F. under a cloudless sky. The winds aloft were southwest as was to be expected of the return flow of the upper level High. The significant point on this curve is the layer of moist air centering around 700 mb. The curve for the 26th shows a large

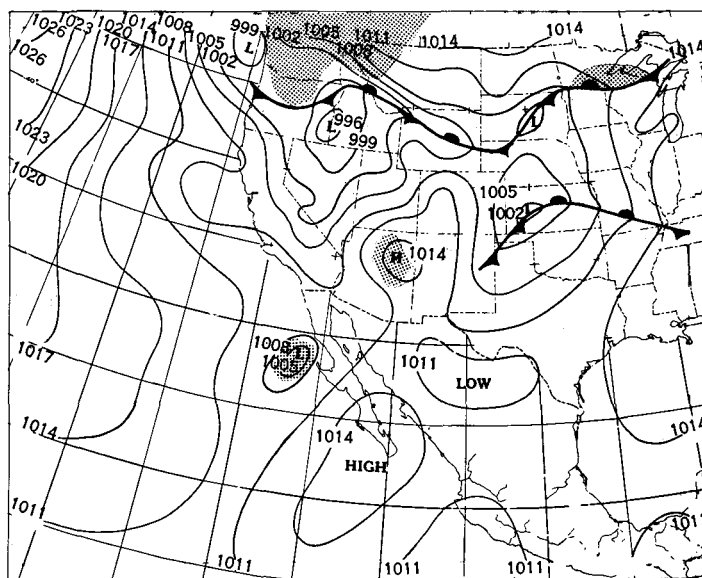


FIGURE 4.—Surface weather chart for 1830 GMT, August 28, 1951.

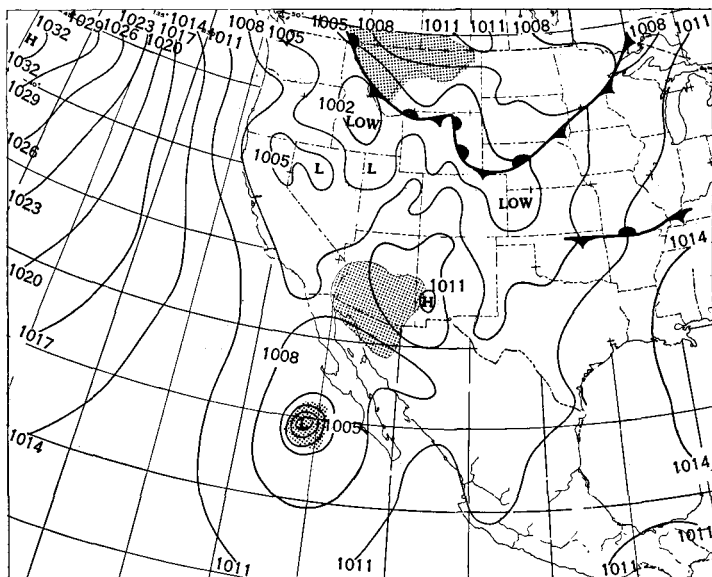


FIGURE 3.—Surface weather chart for 1830 GMT, August 27, 1951. Shading indicates areas of active precipitation.

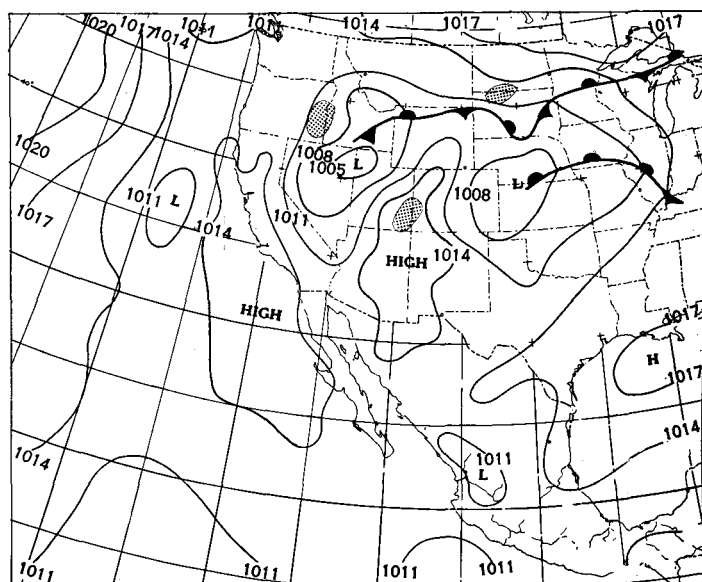


FIGURE 5.—Surface weather chart for 1830 GMT, August 29, 1951.

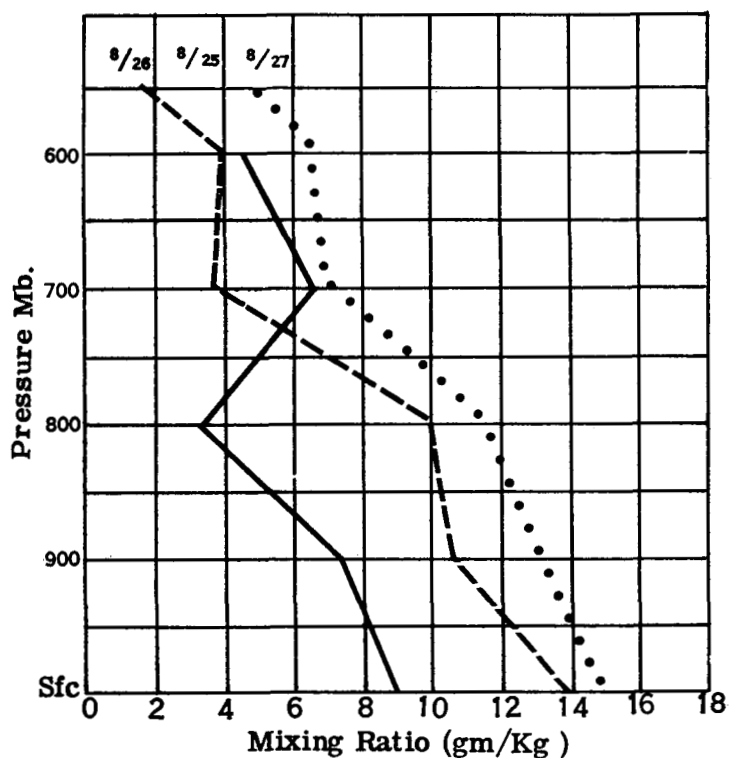


FIGURE 6.—Moisture soundings (grams of water vapor/kilogram of dry air) at Phoenix, Ariz., 1500 GMT, August 25 (solid line), August 26 (dashed line), August 27 (dotted line), 1951.

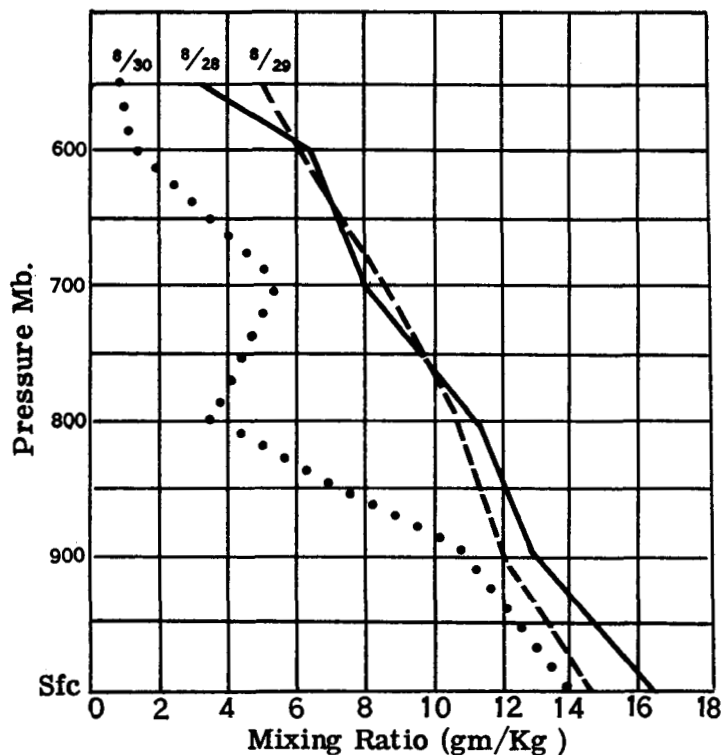


FIGURE 8.—Moisture soundings (grams of water vapor/kilogram of dry air) at Phoenix, Ariz., 1500 GMT, August 28 (solid line), August 29 (dashed line), August 30 (dotted line), 1951.

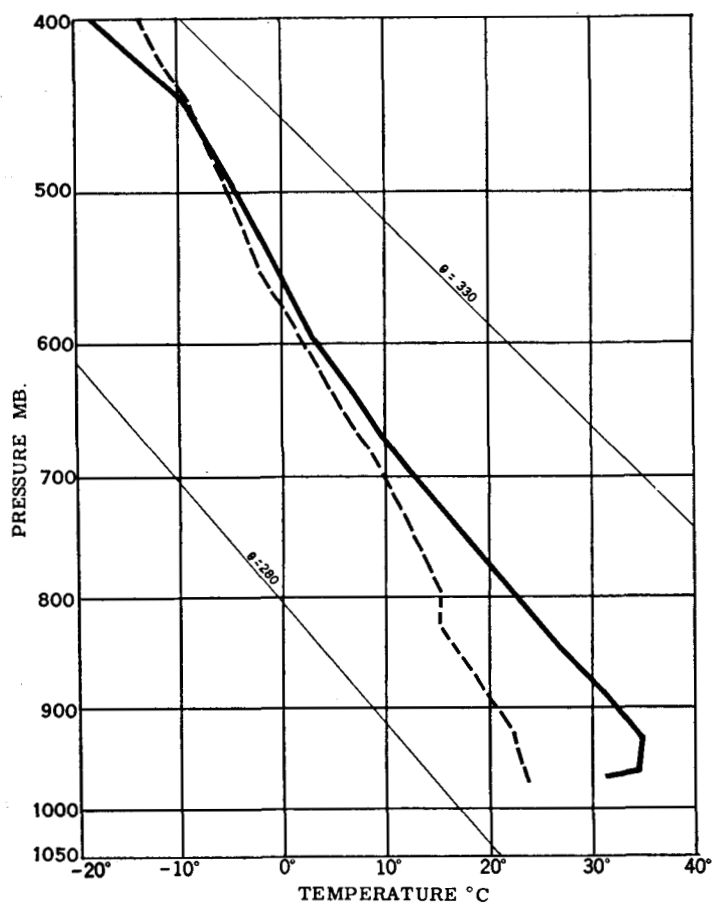


FIGURE 7.—Temperature soundings (on a pseudo-adiabatic diagram) at Phoenix, Ariz., 0300 GMT, August 25 (solid line), August 27 (dashed line), 1951.

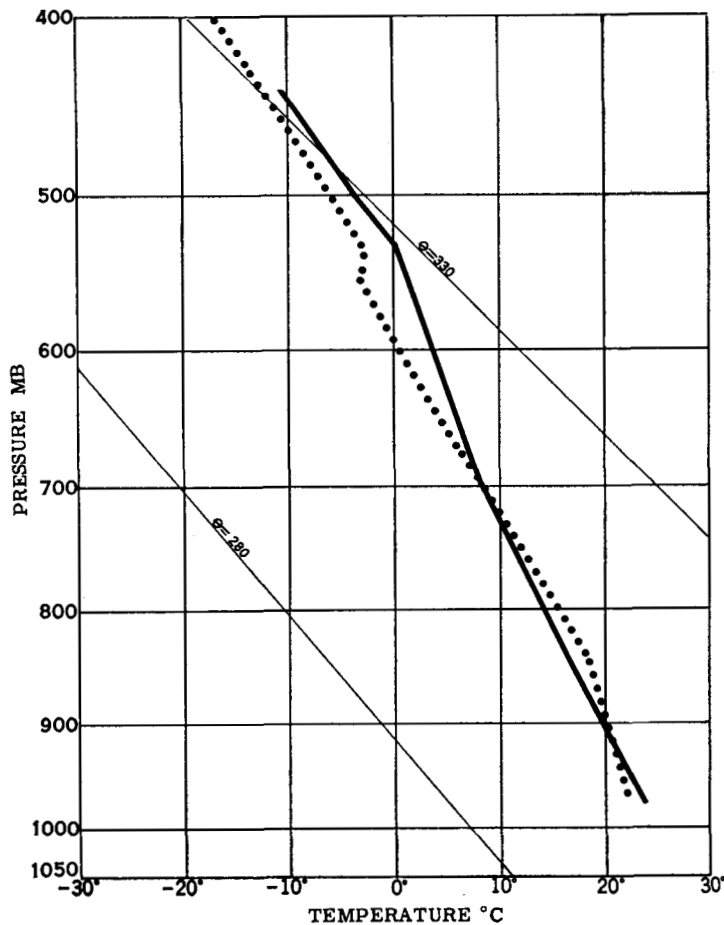


FIGURE 9.—Temperature soundings (on a pseudo-adiabatic diagram) at Phoenix, Ariz., 0300 GMT, August 29 (solid line), August 30 (dotted line), 1951.

24-hour increase from the surface to approximately 800 mb. with some decrease from 730 to 550 mb. Over the next 24 hours, the curve (27th) shows increases from the surface to 550 mb., with the greatest increase centering around 700 mb. and with a second maximum from 600 to 550 mb. Comparing the curves for August 25 and 27, the 48-hour change shows a region of maximum moisture increase from 900 to 770 mb. with a second maximum from the surface to 900 mb. In other words, the greatest increase of moisture was in the lower levels. This fits in with the other evidence previously presented.

As shown in figure 7, the Phoenix temperature soundings for the same 2 days (25th and 27th) indicate that the air on August 25 was conditionally unstable from the surface to 680 mb. where it became stable with respect to the moist adiabatic lapse rate. It is interesting to note the development of an inversion at the surface at 0300 GMT, on the 25th. In 48 hours the change of air mass was reflected by the moist adiabatic conditions from the surface to near 550 mb. At the same time strong cooling had taken place as indicated by the separation of the two curves from 800 mb. down to the surface.

The period of decreasing moisture at Phoenix is shown by the curves of figure 8. The curves of August 28 and 27 (fig. 6) show close agreement as conditions in the free air were not too different during the interval. In the following 24 hours, the curve of the 29th shows the moisture content of the air had decreased slightly from the surface to 750 mb. without any particularly significant change above 750 mb. However, the curve of August 30 indicates a strong drop off of moisture had taken place at all levels from the surface to 550 mb. The smallest change

was found from the surface to 900 mb., which is to be expected in light of the 3-day soaking rain and some flooding over the land. The curve shows the greatest influx of drier air took place at about 800 mb.

The curve of August 30 seems to have been approaching the same shape and values as the "pre-rain" curve of the 25th, although the moisture values were still generally higher.

The temperature soundings for August 29 and 30 (fig. 9) show a 24-hour change to warming between 920 and 720 mb. and a cooling above to 400 mb. Apparently on August 30, the heat from the sun was being spent, mostly, in evaporating water from the earth's surface. This is indicated by the slow return of the moisture curve to the values preceding the rain.

While the rains continued in Arizona the upper circulation remained essentially unchanged until the 29th. On this date a deepening upper level Low (fig. 1) over Washington and Oregon changed the circulation along the Pacific Coast. The air that now arrived over Arizona, like the air it displaced, had moved long distances over water. However, the water, this time, was quite a bit colder and consequently the cold air from the more northern latitudes possessed a more stable lapse rate. The stable air with lower moisture content moved in over the Southwest and brought clearing weather that finally enabled the temperature to return to the more normal 100° readings.

REFERENCE

1. V. J. Oliver, "The Weather and Circulation of August 1951," *Monthly Weather Review*, vol. 79, No. 8, August 1951, pp. 160-163.

